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Recent Trends in White Shrimp Stocks of the Northern Gulf[1]

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Abstract

Fishery statistics compiled since 1956 by the Bureau of Commercial Fisheries are used to determine seasonal and long-term trends in the abundance of white shrimp along the northern Gulf coast. Special reference is made to that portion of the coastal stocks contributing most to this species' over-all commercial production, namely, that portion inhabiting Louisiana's marshes and offshore waters. By providing some insight into population age structure, commercial size composition data aid in hypothesizing causes of the sharp production drop in 1957.

HISTORICALLY THE MAINSTAY of one of the Nation's major fisheries, the white or common shrimp, *Penaeus setiferus,* no longer holds the spotlight. During the past 2 decades, which have seen a great expansion in the industry utilizing the Gulf of Mexico's shrimp resources, this species has become increasingly subordinate in importance to two related forms, *viz.,* the brown and pink shrimp, *P. aztecus* and *P. duorarum* respectively. This is not to say, however, that the condition of its stocks now merits only passing attention for in some coastal areas and at certain seasons the white shrimp still represents the cornerstone of local economy.

Recent statistics disclose that the white shrimp contributes roughly 25 per cent to the annual production of all shrimps in the United States Gulf coast area. Over the period 1956-1960, commercial landings originating in northern Gulf waters ranged from a low of 18.6 million pounds (1957) to a high of 47.0 million (1960). Their dockside value within the same period rose from a corresponding low of 6.9 million dollars in 1957 to 14.8 million the following year. Note here that the ratio between quantity and value of landings is not necessarily constant but fluctuates according to economic conditions within and without the industry.

Because of its former (apparent) dominance and related significance as a fishery product, much more attention has been given the biology and dynamics of the white shrimp than has been accorded the other commercial varieties. But, despite advances made, large gaps still exist in our knowledge of what factors, natural and artificial, exercise the greatest control over the magnitude of commercial shrimp stocks — be they brown, pink, or white. Determination

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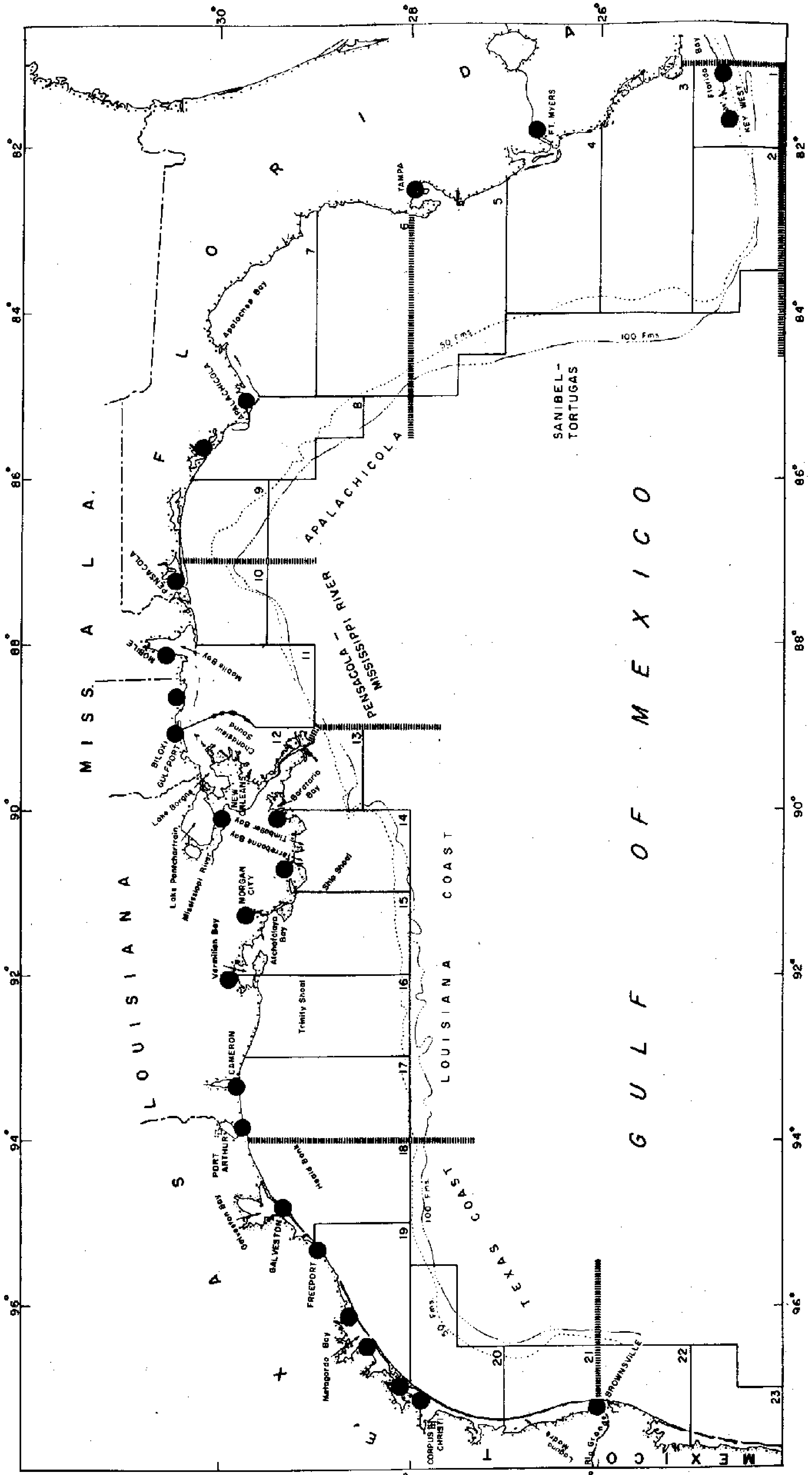

of these factors and of how they operate to cause adverse fluctuations in supply, persists as a major objective of shrimp research.

Acknowledging the usefulness of commercial fishery statistics in achieving such an objective, the Bureau of Commercial Fisheries initiated a Gulfwide industry canvass in 1956. It has since functioned continuously, gathering and compiling a wealth of detailed information which includes statistics of fishing operations, shrimp production, and landings' composition (species and size). Published tabulations thereof provided the data used throughout this report. Insofar as these data permit, recent trends in the relative strength of a major portion of the northern Gulf's white shrimp stocks are described, and an explanation for one instance of an untoward drop in yield is attempted.

White Shrimp Biology and Distribution

A considerable literature dealing with the taxonomy, morphology, general biology, and ecology of the white shrimp has accumulated over the past 30 or so years. For an introduction to detailed information on these subjects one should consult the general works of Burkenroad (1934, 1939); Pearson (1939); Young (1959); and Lindner and Anderson (1956). Suffice it to say here that the white shrimp is one of perhaps a dozen and a half Gulf of Mexico Penaeidae, a family of shrimps having world-wide distribution but occurring mainly in tropical and subtropical zones. Its life history is characterized by an egg and larval phase in the open sea, a postlarval and juvenile phase in inshore brackish waters, and an adult (reproductive) phase, again, in the open sea. Off the United States Gulf coast, the reproductive season extends over the greater part of each calendar year with heightened activity evident at the beginning (spring) and toward the end (fall).

In the Gulf of Mexico, white shrimp are found in widely varying quantity on the continental shelf from the vicinity of Apalachicola (Florida) westward along the coast and then south to the Bay of Campeche (Figure 1). Densest concentrations seem to prevail in the more humid regions where a low-lying coastline consists of a series of broad estuarine systems. One such region harboring a sizable population is the east-Mexican coastal area between Tupilco and Carmen. But by far the more important is that section of the United States coast stretching from Apalachicola to central Texas. Within it, specifically in and seaward from Louisiana's vast estuarine complex, white shrimp stocks attain peak strength. Although the preponderance of stocks at all coastal points lies within the 15-fathom contour, the deeper limit of the species bathymetric range is in the neighborhood of 40 fathoms.

Manner and Intensity of Fishing

All penaeid shrimps, being bottom dwellers during all but their earliest life history stages, are readily captured with bottom trawls of any type. Otter trawls of varying dimensions are, however, the conventional gear employed by the Gulf shrimp fleet. Contrasted to the earlier practice of fishing one large (60- to 110-foot) "flat" or "balloon" net, current procedure in the case of most vessels plying offshore waters consists of fishing a pair of smaller (40- to 50-foot) nets. Small craft restricted to inshore waters have the capacity

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FIGURE 1. System for coding origin of shrimp landings and position of commercial shrimping operations in the northern Gulf of Mexico. Shaded circles indicate principal landing ports.

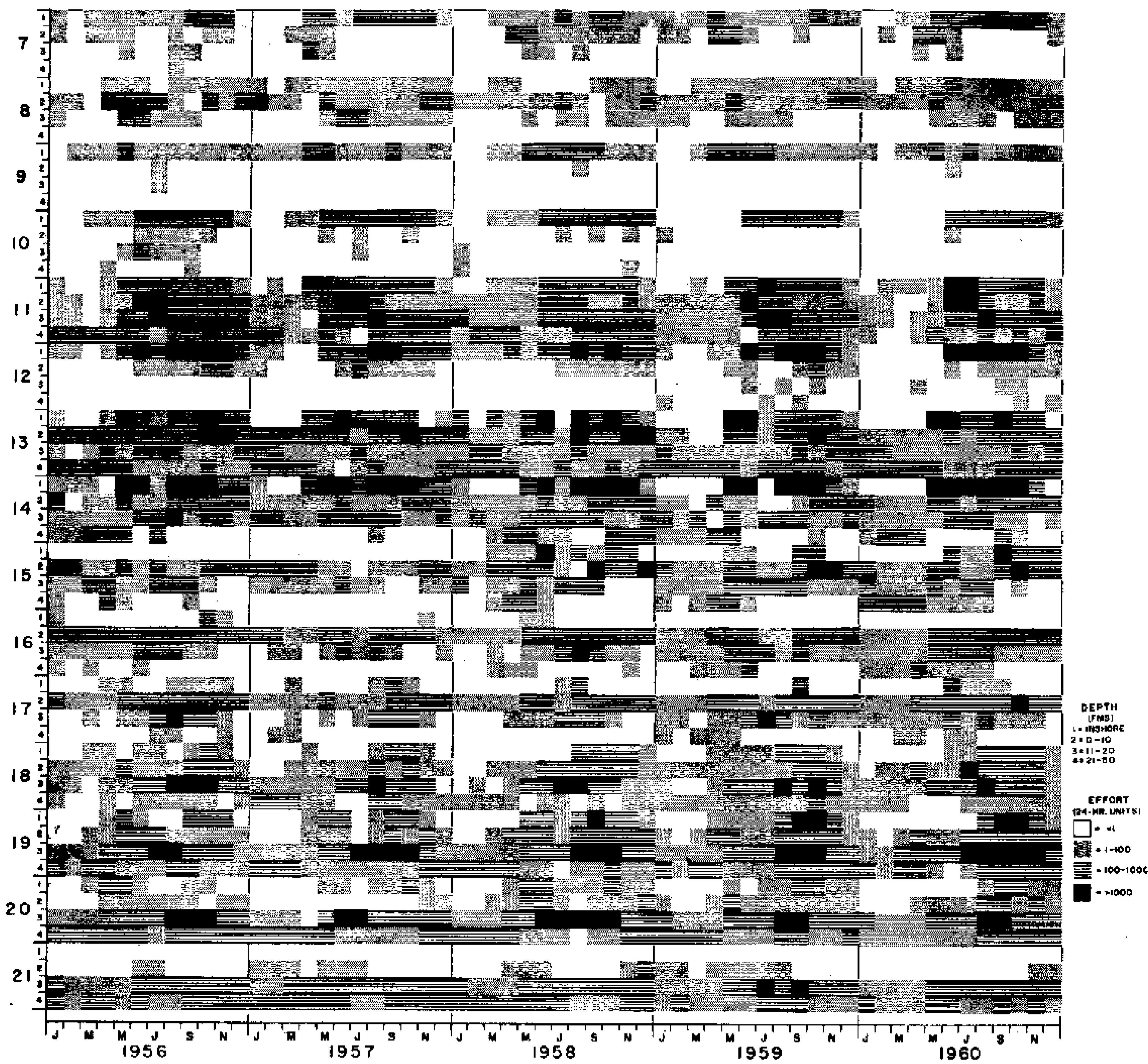

FIGURE 2. Distribution of commercial shrimp fishing effort on the continental shelf of the northern Gulf of Mexico (statistical subareas 7-21), 1956-1960.

to pull but a single net, the width of which ordinarily does not exceed 50 feet or is fixed at a lesser dimension by state law. In all fleet components, mesh size (stretched) varies little from 2¼ inches. More detailed descriptions of shrimp fishing gear and gear operation may be found in Knake et al. (1958), Robas (1959), and U.S. Fish and Wildlife Service (1958).

White shrimp are ordinarily fished during daylight hours, this pointing up a difference in habits which makes the brown and pink species more vulnerable to capture during hours of darkness. Most fishing trips in northern Gulf waters are of a day's duration, measured from departure to first landing. Trips exceeding 5 calendar days are comparatively rare. Depending on the seasonal occurrence of the various species, trawling may be done only at night, only during hours of daylight, or around-the-clock. There has been no recent evidence, in situations where two or three of the common varieties overlap in occurrence, of the industry having special preference for a particular species and directing fishing effort accordingly. The price differential between species being negligible, major considerations are abundance, accessibility, and size.

To enhance their usefulness, statistics of fishing operations and production are reported systematically on the basis of coastal areas and depth zones into which the fishing grounds are subdivided (Figure 1). Intensity of shrimp fishing on the northern Gulf's continental shelf, as disclosed by effort statistics so reported, is shown diagrammatically for the period 1956-1960 in Figure 2. Note that season after season, certain well-defined areas receive the brunt of the total effort expended. More important, however, observe that some trawling is done the year round in nearly every coastal subsubarea. Knowledge of how fishing effort is distributed with respect to the known range of exploited stocks greatly aids the derivation of meaningful indices to each species abundance. In the case of the white shrimp, it is readily apparent that hardly a portion of its stocks escapes the trawl. In fact, one might facetiously ask if this species stocks couldn't be "sampled" less heavily and still obtain reasonably good measures of their relative size. There is little doubt that the grounds included in Gulf statistical subareas 13 through 21, inshore to 20 fathoms, comprise one of the world's heaviest fished areas.

Commercial White Shrimp Yield

Analytical treatment of extensive fishery statistics is often facilitated by grouping them on the basis of small geographical units. This was deemed necessary in the case of upper Gulf shrimp fishery statistics and four sections were consequently delineated. From east to west they are: the Apalachicola area (statistical subareas 6-10); the Pensacola-Mississippi River area (subareas 11-12); the Louisiana Coast area (subareas 13-17); and the Texas Coast area (subareas 18-21) (see Figure 1).

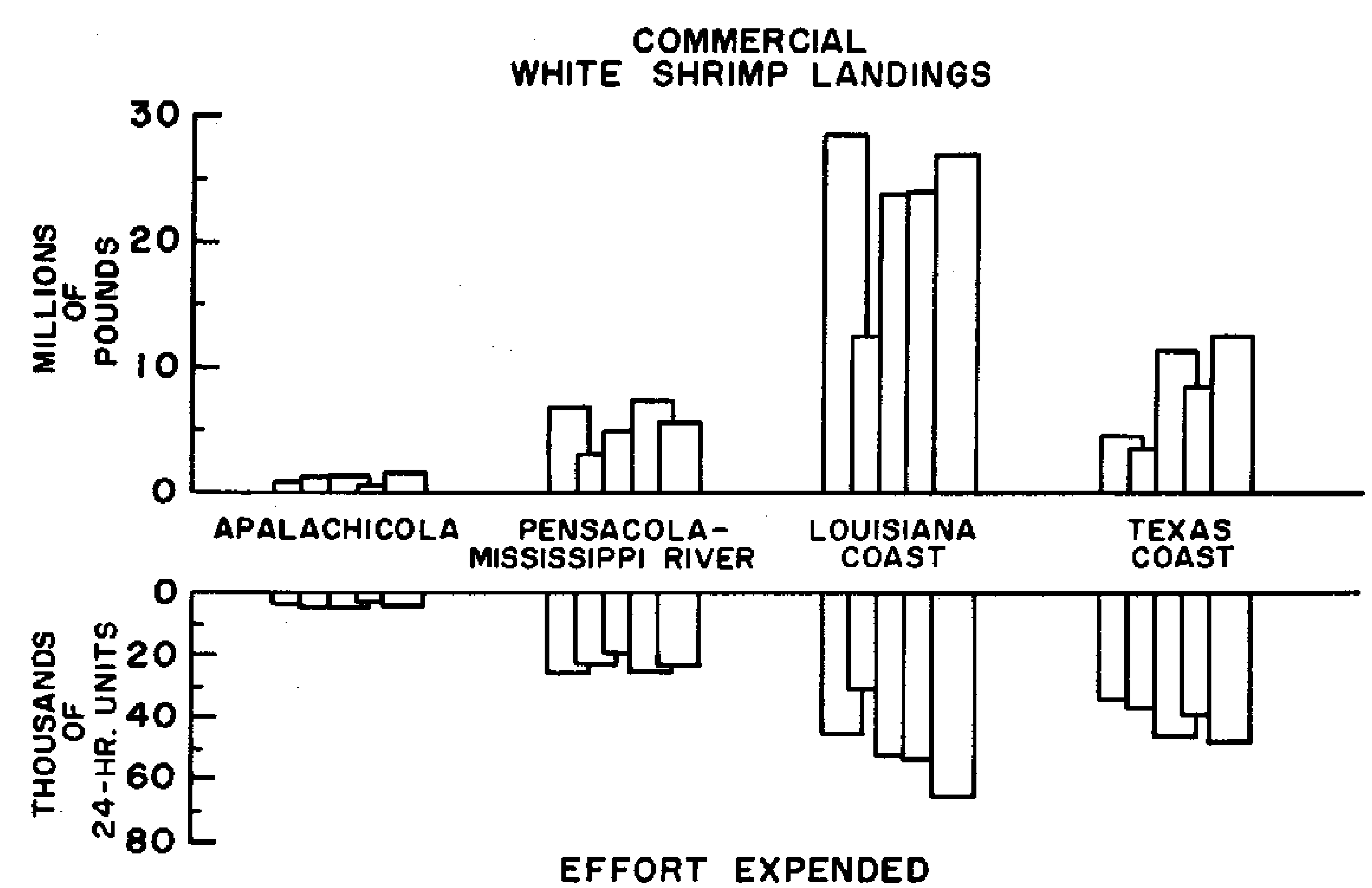

FIGURE 3. Annual white shrimp production and corresponding fishing effort in the northern Gulf coast area. Data for the years 1956-1960 are shown consecutively (left to right) for each coastal section.

Comparing the annual yield patterns in each coastal section, one merely concludes what was stated earlier, namely, that waters in the Louisiana area harbor the greater part of Gulf of Mexico white shrimp stocks (Figure 3). For this reason (as well as that of space limitations) the following discussion will be restricted to a treatment of statistics arising from fishing operations in the Louisiana Coast area, the thought being that trends, etc., elicited therefrom would largely reflect those of the coastal stocks as a whole.

Of the total shrimp produced commercially in this area, the white shrimp makes up about 40 per cent. Over the years 1956-1960, its annual landings averaged 60 per cent of upper Gulf totals, ranging from a low of 10.5 million pounds in 1957 to a high of 28.7 million the previous year (Figure 4A). Ex-vessel values for the same years were 4.5 million and 8.3 million dollars. On the average, inshore catches accounted for roughly 40 per cent of the area's annual white shrimp harvest, and consisted of 70, 28, and 2 per cent small, medium, and large shrimp[2] respectively. In contrast, relative composition of offshore landings was 25, 40, and 45 per cent in the same categories. As is well known, practically all of the small and much of the medium size shrimp is marketed canned or dried, whereas the larger sizes are distributed fresh or frozen.

Seasonally, white shrimp landings in the Louisiana Coast area (as along the northern Gulf coast generally) peak in November, with the bulk of each year's harvest accumulating over the last 3 months of the calendar year (Figure 4A). After the peaks are reached, yields of inshore population phases usually drop off more abruptly than do those of offshore phases. Yearly trends in annual offshore and inshore production exhibited a sharp drop in 1957 followed, in the case of offshore production, by a slight rise during the period 1958-1960, and in the case of inshore production, by nothing more than a slightly undulating pattern over the same period. The over-all drop in 1957 was of very great concern (Viosca, 1958) and culminated a gradual decline in white shrimp production which began soon after landings peaked in 1945 at well over 110 million pounds.[3]

The cause or causes of the long-term reduction in white shrimp supplies will probably never be defined because of the lack of appropriate biological and environmental measurements with which to formulate hypotheses, let alone test them. On the other hand, recent data at least offer some assistance in speculating as to what brought about the 1957 situation.

Population Trends

The fished portion or exploited phase of a shrimp population shall be defined as that fraction of the total population or stock whose lower limit is fixed either by the specifications of the gear (mesh size) most commonly employed by the fishing fleet, or by the minimum size of shrimp that will or can be accepted by processors. Since all statistics of commercial shrimp yield are reported in terms of weight, the foregoing connotation (stock) is further modified to "fishable biomass." It is clear that commercial fishery statistics can only provide information about a population's fished or exploited phase.

[2]Small shrimp are defined as those of uniform weight such that the numbers of whole individuals per pound would exceed 40, large shrimp as those that would number 15 or less.
[3]Information taken from "Fishery Statistics of the United States—1956," Statistical Digest No. 43, U.S. Fish and Wildlife Service, 1958. Since large-scale exploitation of the brown shrimp was not yet underway, practically all of this production is assumed to have consisted of white shrimp.

For a short interval of time, in this case 1 month, a catch (in weight)-effort ratio is computed for each subsubarea within the species range (*re* Figure 2). A weighted average ratio for all subsubareas is then determined, the sizes of each of these units constituting the weighting factors (Gulland, 1955). This ratio, the mean catch per unit fishing intensity, is theoretically proportional to the population's harvestable fraction and is referred to herein as a fishable biomass index. In effect, it is a density estimator in which the effects of uneven distribution of fishing effort are eliminated by a process analogous to stratified sampling. Note also that it yields indices having comparability in successive time increments. Thus a change in apparent density suggested by a difference in successive values of the simple catch-effort ratio could be wholly due to a change in effort distribution rather than a real change in population density. Employing the mean ratio of catch to fishing intensity circumvents this possibility.

Among the assumptions being made here, the following should be especially noted: (1) any white shrimp otherwise vulnerable but not available because of untrawlable bottom comprised a constant fraction of this species fishable biomass; (2) movement of commercial-size white shrimp into and out of the Louisiana Coast area was negligible or offsetting; and (3) characteristics of inshore and offshore fishing fleets (including gear specifications) changed little or not at all during the period of study.

Monthly (1956-1960) indices of fishable white shrimp biomass in the Louisiana Coast area are plotted serially in Figures 4B (offshore waters) and 4C (inshore waters). In each case there were generated typical time-series possessing distinct seasonal oscillations which obviously reflect to a great extent the species reproductive rhythm. No attempt was made to fit trend-curves by means of high order polynomials or other sophisticated statistical techniques, the feeling being that smooth curves fitted by eye would more than satisfy the purposes of this study. Indeed, the absence of numerous points would have, in the case of data plotted in Figure 4C, precluded the former approach anyway.

Though seasonal or cyclic oscillation is by far the dominant component in each time-series, the trend component is still discernible, albeit almost imperceptibly so. By plotting the monthly average indexes for each of the 5 years represented, seasonal effects were eliminated and the long-term components more clearly shown (right hand side of Figures 4B and 4C). In both offshore and inshore populations, these could be adequately described by straight lines, each characterized by a slight but yet distinctly negative slope. A straight line was, in fact, fitted to the monthly indices in Figure 4B. Unsystematic or "random" residual was almost negligible in both instances.

Having determined that the mean white shrimp biomass declined over the 5-year study period — nearly proportionately so in successive years — the problem remains to specify whether this actually signified a trend in the true sense of the word or merely part of another oscillatory component with mean period greater than that of seasonality. Regardless, determination of the causal systems underlying either of such conditions is a major objective of shrimp research. The most promising approach thereto involves the technique of serial or lag correlation. Here, the time-series of interest is correlated with a time-series of a factor which, on intuitive grounds, exercises some degree of control over it, and whose values lag a specified interval of time behind those of the former. To illustrate in the case of shrimp population research, one

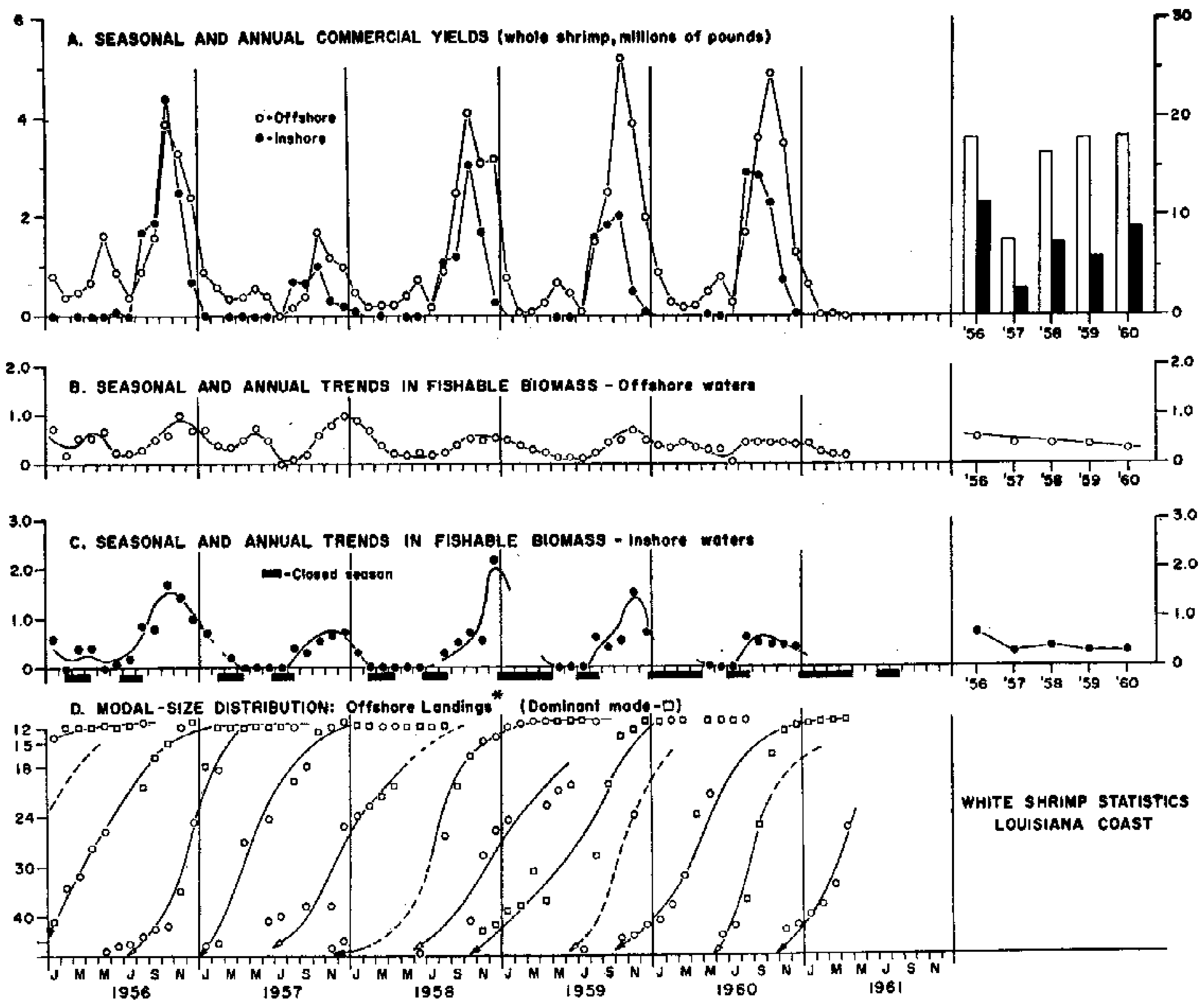

FIGURE 4. White shrimp catch and population statistics — Louisiana coast (statistical subareas 13-17), 1956-1960.
*Numbers of whole shrimp per pound

might consider evaluating the degree of relationship between the time-series of a species commercial biomass and the time-series of tidal heights, fresh-water influx, etc. in inshore or estuarine waters where the common species pass through critical stages in their early development. The time lag, of course, would be roughly the average amount of time lapsing between the mid-point in each age class's estuarine phase and the point in time when it attains maximum biomass in transition or offshore waters. In this instance, the obvious hypothesis is that the survival of each season's reproduction is most closely associated with the quality of environmental conditions during estuarine phases. Analyses of this sort have not yet been attempted mainly because of the relative shortness of biomass time-series.

A comparison of the time-series in Figures 4B and 4C reveals some similarity and thereby corroborates the expected relationship between the two. Major seasonal peaks occurred at about the same time, there being some indication that those on the inshore biomass curve slightly preceded those on the offshore curve. The mean amplitude of oscillations on the inshore curve appreciably exceeded that of oscillations on the other, this reflecting expected mortality during migration from inshore to offshore waters. Secondary peaks appearing on the offshore curve in the first half of each calendar year suggest for white

shrimp a reproductive pattern involving semiannual periods of heightened spawning activity. Also of special interest is the fact that the sharp drop in 1957's yield was not paralleled by a correspondingly abrupt drop in biomass, at least in the offshore population phase.

Age Structure - Fished Population

All commercial shrimp are sold and bought on the basis of their relative size with the largest specimens bringing the highest price. When landings are broken down according to the sizes of shrimp comprising them, the resulting distribution affords some insight into the age structure of the population being fished — provided that the landings are reasonably representative of the population's defined biomass. Any effects of differential bias due to (1) fisherman or gear selectivity; (2) non-uniform distribution of fishing effort with respect to stratification by age within the fished population; (3) minimum-size restrictions; and (4) varying size-grading practices must be assumed negligible, or at least constant in time.

Totals for the seven or eight size categories into which commercial shrimp landings are separated give weight frequency curves whose modes, it is believed, roughly delineate the age classes or "broods" making up the exploited biomass. Monthly weight frequency distributions for each coastal section are obtained by summing, within each size category, the landings from each subarea and depth zone. Plotted serially and fitted with smooth curves, the size-distribution modes trace the progress, from recruitment to disappearance from the fishery, of age classes arising in successive periods of heightened spawning activity. The curve for each class is the typical sigmoid curve describing population growth in terms of weight. For purposes of the following discussion, its disposition with respect to the ordinate is irrelevant, the mid-points of size classes being arranged arbitrarily thereon.

Good representation of vulnerable sizes in landings from offshore waters in the Louisiana Coast area provides a synoptic picture of age structure in what is considered the nucleus of northern Gulf of Mexico white shrimp stocks (Figure 4D). Heightened spawning in November-December and in June-July may be inferred, respectively, from offshore recruitment surges in May-June (light arrows) and again in November-December (dark arrows). Evidence for semiannual peaks of spawning activity can hardly be refuted since this phenomenon has now been shown to recur over a reasonably long period of time. A similar pattern has also been noted for white shrimp stocks elsewhere in the northern Gulf. Plots of modal-sizes from weight frequencies of inshore landings yield essentially the same picture except that dominant modes usually represent smaller shrimp.

Year-to-year variation in the magnitude of peak spawning activity as well as in the chronology of recruitment is obvious from the picture presented in Figure 4D. When reproductive patterns for white shrimp stocks in northeastern and northwestern Gulf areas are compared, it is seen that members of early-season broods (dark arrows) dominate fisheries in both areas but that they attain particular significance in the northwestern Gulf. Secondary yield and biomass modes occurring in May or June (*cf* Figures 4A, 4B, and 4C) are attributed to late-season broods supplementing portions of both the preceding early-season brood and the late-season brood produced 1 year earlier. Spawning populations giving rise to early- and late-season broods are believed to be predominated by survivors of the previous year's corresponding broods. The degree of predominance appears to vary widely, however, being largely dependent upon the relative initial strength and subsequent survival of each half-year class making up a spawning population.

The Greatly Diminished Fishery of 1957

Information such as that depicted in Figure 4D together with, in this case, tentative knowledge of the time lapse and spatial distribution of developmental stages between hatching and recruitment to the offshore fishery, provides a biological framework within which the cause(s) of fluctuations in shrimp yields can be theorized. Of particular interest is the observation that shrimp forthcoming during periods of heightened spawning in November-December and in June-July may be expected to occupy the inshore nursery grounds during, respectively, February-April and August-October. Though there is some question as to the extent to which representatives of the late-season spawning mode utilize inshore areas during the winter months immediately following, it is well known that such areas harbor in great quantity representatives of the early-season spawning peak during late summer and fall. Based on the over-all percentage size composition figures given earlier, inshore landings accumulating over the last 5 months of each calendar year are composed largely of fast-growing members of the same year's early-season brood. On the other hand, offshore landings consist mainly of members of the previous year's early-season brood plus any residuals of earlier broods, including those of the previous year's late-season brood. Some overlap obviously occurs since many individuals attaining fishable size in inshore waters are simultaneously in the process of migrating to offshore waters.

Coinciding with periods of peak inshore and nearshore concentrations of (1) migrating juvenile white shrimp representing 1956's late-season brood and (2) late postlarvae and juveniles representing 1957's early-season brood was the occurrence of intensive tropical storms. Thought to have wrought the most damage to inshore and nearshore biota was Hurricane "Audrey" which hit the Gulf coast just east of the Texas-Louisiana border (statistical areas 16 and 17) on June 27, 1957. Storm surges brought tides of almost 14 feet above m.s.l. in the Cameron, Louisiana, area; 4 feet above m.s.l. in Garden Island Bay, 250 miles to the east; and 3 feet above m.s.l. at Port Aransas, 220 miles to the west. Low-lying areas in Louisiana were inundated up to 25 miles inland (Moore et al., 1957). Tropical storm "Bertha," not quite attaining hurricane intensity, shortly followed "Audrey," striking the coast in the same general area on August 9. The highest accompanying tide, 4.7 feet above m.s.l., was recorded in Vermilion Bay. Although the mechanics involved are obscure, it is conceivable that factors such as: extended periods of high salinity, destruction of cover and food supplies, and excessive turbulence, all induced by extraordinarily high tides, acted corporately to disperse and otherwise exert greater-than-normal mortality in white shrimp populations during vulnerable inshore phases.

Excessive fishing on spawning populations giving rise to early- and late-season broods in 1956 and early-season broods in 1957, is discounted as a contributing factor. Comparatively speaking, indices of mean biomass for offshore and inshore population phases suggested that white shrimp spawning potential in 1956 and early 1957 was more than adequate (*cf* Figures 4A and 4B). A low inshore biomass in late 1957 did suggest, however, the low survival of that year's early-season brood during pre-juvenile stages.

Although effort expenditure fell off during the latter half of 1957, the drop was not sufficient to account for the disproportionate drop in landings. Effort expended on inshore and offshore grounds in the Louisiana Coast area during July-December, 1957, was 72 and 51 per cent, respectively, of that expended during the same period in 1956. Corresponding landings, on the other hand, were only 25 and 36 per cent of those recorded in 1956. In Texas, about the same amount of effort expended in offshore waters during the latter half of 1956 was recorded for 1957, but the corresponding white shrimp catch declined 43 per cent. By way of contrast, the Texas inshore fishery doubled its production over the same period with only a 55-per cent increase in effort expenditure. Most of this, however, came from bays along the southern half of the Texas coast, well outside the main area of storm damage.

Record low white shrimp landings from Louisiana waters in 1957 must therefore be ascribed more to a real (though momentary) decline in population strength than to relaxed exploitation during a period when the white shrimp normally attains peak density and avialability. The import of factors contributing to this decline is also manifested in the magnitude of the following year's landings. Thus, notwithstanding an immediate return of effort expenditure to its 1956 level (Figure 3), restoration of landings to their former (1956) level has lagged for 3 years.

The Fishery's Recovery

The effectiveness of newly enacted closed-season laws (inshore waters: Louisiana, 1958) in bringing about the fishery's recovery would appear debatable. Most noteworthy, perhaps is the fact that these closures generally coincide with or occur shortly after seasonal ebbs in the white shrimp's nursery ground phases. Records show that in years prior to this more rigidly enforced closed-season law (1956-1958), white shrimp landings (inshore) over the period December-April averaged but 6 per cent of each year's total. The closed season, mid-December through April, in effect, protects (1) residuals of early-season broods, most of whose representatives will have already passed to offshore waters by the time the fishing season closes, and (2) late-season broods, the postlarvae of which begin to move into inshore areas at about the same time. Most members of the less important late-season broods will have attained commercial size when the fishing season reopens in May. Though now protected in inshore areas, these broods have never contributed as significantly to inshore or offshore fisheries as have their early-season counterparts.

Conversely, early-season broods which are fished heavily in inshore waters during late August through November are the same broods dominating (for the most part in the following year) the offshore fishery which reaches peak production almost simultaneously. For all practical purposes, they support the white shrimp fishery but are not now afforded anywhere near the extensive protection given late-season broods.[4] Nor is additional protection called for unless a significant relationship between fishing rate and brood size (or recruitment) manifests itself.

Available statistics do not permit establishing whether or not such a relationship prevailed. But despite improved yields, the white shrimp stock in the

[4]The closed season, early July to mid-August, offers early-season white shrimp broods protection from excessive fishing on pre-commercial sizes. Inshore production of small brown shrimp has not been affected by either closure.

northwestern Gulf has shown little sign of recuperating from the reduced level of 1957. This could be due to too heavy fishing pressure having been exerted too soon after an extreme population setback. If each year's dominant early-season broods are roughly separated by analyzing only those statistics for the months July-December, plots of mean annual biomass against corresponding fishing intensity mildly suggest such a possibility (Figure 5). In Louisiana's offshore waters, quadrupled fishing intensity in 1957 had the apparent effect of delaying initiation of a recovery trend until the following year. Unfortunately for the white shrimp, 1958 was a year in which record high shrimp prices induced extra-heavy fishing pressure. Most of this was directed at the brown shrimp with the low-level white shrimp population suffering coincidentally. Effects of exploitation inshore are also well illustrated

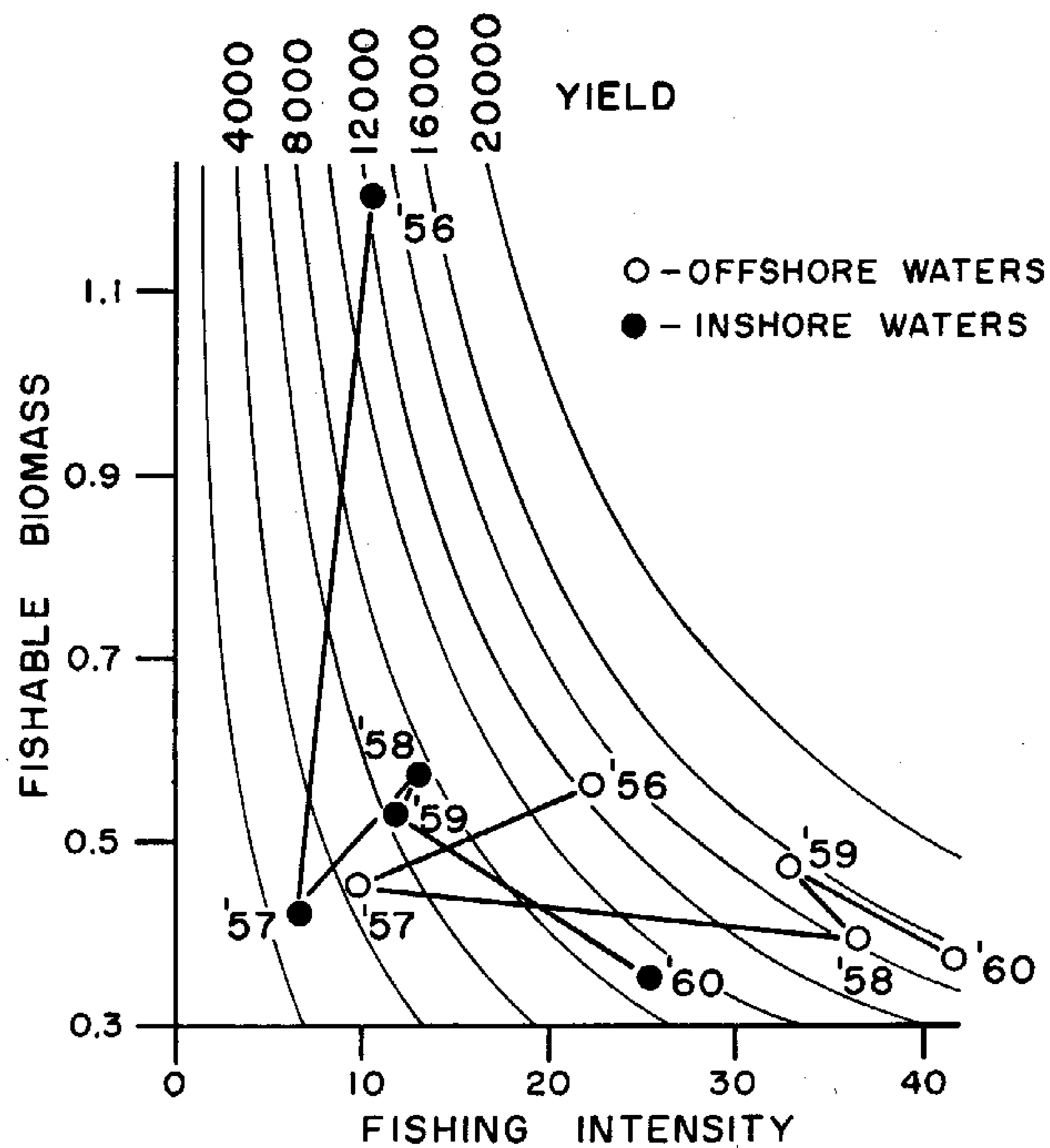

FIGURE 5. Relationship between exploitable biomass and degree of fishing intensity. [Data refer to dominant half-year classes (successive early-season broods) of white shrimp in the Louisiana Coast area (1956-1960) as isolated through analysis of commercial fishery statistics combined over the months July-December only.]

and, in fact, may have controlled the pattern which developed. A doubling of inshore fishing intensity in 1958 seemingly contributed to the decline in the offshore population phase the same year, and in itself may have stifled an earlier upsurge in the over-all population. Relaxation of fishing pressure on the inshore phase in 1959 resulted in concomitant recovery in offshore (spawning) population phases. A more comprehensive analysis would have to incorporate precise knowledge of what proportion of each year's (last semester) offshore biomass consisted of (1) the same and (2) the previous year's reproduction.

Data for 1961 are incomplete but those for 1960 indicate a low inshore biomass as well as a reduced offshore biomass late that year. The former condition forewarned a reduced offshore (commercial) biomass while the latter intimated a reduced spawning population and hence a small early-season brood the following year. Both conditions portended a generally diminished production in late 1961. Probable adverse effects of the high fishing intensity in offshore waters in 1960 will likely not be noticed until late 1962. Meanwhile, it is believed that the high exploitation of 1960's early-season brood will be largely responsible for a marked drop in 1961's offshore production.

In summary, the question is not so much one of whether, following periods of high natural mortality, fishing intensity should be regulated at all, but one of deciding at what season such regulation would be most effective. Little benefit can be expected from suspending fishing in inshore waters when population phases there are at minimal density. On the other hand, closed seasons or regulated fishing in offshore waters supporting multi-species fisheries are, practically speaking, out of the question altogether.

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